instruction manual

AC
VOLTAGE REGULATORS

SORENSEN
A Unit of Raytheon
Richards Avenue, South Norwalk, Connecticut

GENERAL INFORMATION

PLEASE READ THIS MANUAL. We think it will help you to obtain the maximum performance from your new Sorensen instrument.

SHIPPING DAMAGE

Sometimes instruments are damaged in transit. We strongly suggest that you inspect and test your instrument as soon as you receive it. If the instrument is damaged or if it fails to operate properly, you should ask the carrier to inspect the shipment. The carrier's claim agent will prepare a report of damage which you should send to us. We will then tell you how to have the instrument repaired or replaced.

SERVICE INFORMATION

If you have any questions about the operation, repair, or servicing of a Sorensen instrument, please contact our local representatives. (A list of representatives is included with this manual.) If it is more convenient you may contact us directly at the Service Department, Sorensen, Richards Avenue, South Norwalk, Connecticut.

IMPORTANT

BE SURE TO INCLUDE THE MODEL & SERIAL NUMBER IN ALL CORRESPONDENCE CONCERNING THIS INSTRUMENT. WITHOUT THIS INFORMATION WE MAY NOT BE ABLE TO GIVE YOU PROMPT AND ACCURATE SERVICE.

RETURNS TO THE FACTORY

Should you decide to return an instrument to us for repair, please contact us for authorization to make shipment. We have a number of local service facilities in the United States and Canada which are equipped and staffed to provide you with fast, efficient service. For this reason, we reserve the right to refuse unauthorized shipments to our plant.

WARRANTY

This instrument is warranted by Sorensen/Unit of Raytheon, to be free from defects in material and workmanship. Our obligation under the warranty is limited to servicing the instrument and replacing defective parts* when the instrument is returned to the factory with transportation charges prepaid. No other warranties may be implied. The period of warranty is one year after the delivery of the instrument to the original purchaser. Defects caused by improper operating conditions, accidents, misuse, negligence, and the alteration or removal of the nameplate, will void the warranty.

*With the exception of tubes and fuses.

INSTRUCTION MANUAL

SORENSEN AC VOLTAGE REGULATORS

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SORENSEN, *A UNIT OF RAYTHEON*, Richards Avenue, So. Norwalk, Conn.

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II. SPECIFICATIONS

Following are the basic general specifications applicable to all Sorensen AC Regulators. More specific details on electrical specifications will be found in Table I and an on miscellaneous specifications including controls, input currents and weights in Table II.

Electrical Specifications

(Also note Table I)

Input Voltage Range 95-130 volts AC (or 190-260 volts on "-2S" models). See also graphs A, B, and C.

Output Voltage Rated at 115 volts AC (230 volts AC in "-2S" models) but adjustable between 110 and 120 volts (220 to 240 in "-2S" models).

Regulation Accuracy Plus or minus 0.1% against line or load (plus or minus 0.5% in 400 cycle models) at the nominal input frequency with a resistive load. Normally, the output will deviate (within specifications), both plus and minus, at the preset voltage. Sometimes, however, the deviation will be all plus or all minus.

Time Constant When an abrupt change occurs in the input voltage or in the load, an instantaneous change in output voltage occurs. The magnitude of this change depends on the magnitude of the change in input voltage or load. A finite time is necessary for the Regulator to restore the output voltage from its maximum deviated value to the normal value. Input line transients of shorter duration than the "time constant" will appear in the Regulator output. Time Constants for the various Regulators are listed in Table II.

Input Frequency Range 45 to 65 cycles in standard Models, factory centered at either 50 or 60 cycles. 360 to 440 cycles in 400 cycle Models, factory centered at 400 cycles.

Input Current at Full Load See Table II.

Power Factor Range 1.0 to .7 power factor lagging. See graph C for details.

Load Range Zero to full load. Model number indicates full load rating in VA. On some models, a slight deviation in regulation accuracy may occur below 1/10 load.

Harmonic Distortion 3% maximum in 50 and 60 cycle Regulators. 5%* maximum in 400 cycle Regulators. This rating applies to a nominal input frequency of 50, 60, or 400 cycles. The harmonic distortion rating applies only under conditions of a sinusoidal input voltage, since input distortion can cause appreciable output distortion. Maximum distortion is 5% in "-SH" (hermetically sealed) and "-SF" ("Fosterited") Models. See also graphs D and E.

Ambient Temperature Range 0 to +40°c in 50 and 60 cycle Models, −40°C to +50°C in 400 cycle Models.

Temperature Compensation Temperature compensation is employed to reduce the output voltage change that would be present when the ambient (above) is changed over this wide range. The output voltage may shift ±0.5% over this wide range, but the regulation against line or load will be maintained.

Controls The controls are located on the front panel. Refer to Section III, "Installation and Operation", for information on switching arrangements provided. See also table II. A fuse is provided which protects the control circuit only. It does **not** disconnect the power circuit. A pilot lamp is provided which indicates when input power is on. This lamp is located on either the primary or the filament winding of power transformer T1. The voltage adjustment control permits ample voltage adjustment as rated. Refer to Section III under Protective Devices for information concerning safety devices.

It must be noted that to completely disconnect all possible voltages from the load or circuitry internal to the unit, the power switch should be off or the connection to the main power opened. Removing a fuse will not completely remove all voltages from the unit or the load. See the schematic supplied with the unit for details.

* On some 400 cycle Regulators a slight deviation may occur on 0-1/10 load, increasing distortion to 10%.

TABLE I
ELECTRICAL SPECIFICATIONS

MODEL	150S 150SF 250S 250SF 500S 500SF 500SH 1000S 1000SF 1000SH 2000S 3000S 3000SH 5000S* 10000S 15000S	1000-2S 3000-2S 5000-2S* 10000-2S 15000-2S	D250 SAN D500 SAN D1200SAN D2500SAN
INPUT VOLTAGE RANGE	95-130	190-260	95-130
OUTPUT VOLTAGE RANGE	110-120	220-240	110-120
FREQUENCY	50cps ± 10% ** 60cps ± 10%		400cps ± 10%
REGULATION ACCURACY AGAINST LINE CHANGES	±0.1% at nominal frequency with a resistive load		±0.5% at nominal frequency with a resistive load
REGULATION ACCURACY AGAINST LOAD CHANGES			
HARMONIC DISTORTION	3% Maximum ** (5% Maximum on "SF" and "SH" Models)		5% Maximum
AMBIENT TEMPERATURE RANGE	0°C to +40°C		−40°C to 50°C
PHASE	Single		
POWER FACTOR RANGE	Unity to 0.7 Lagging		
LOAD RANGE	Zero to Full Load		
TEMPERATURE COMPENSATION	All Models		

* For complete service information, see Instruction Manual No. 110.

* For complete service information, see Instruction Manual No. 14-1956, Models 5000 and 5000-25

MISCELLANEOUS SPECIFICATIONS

(See also Table II)

TIME DELAY

In all models, there is a time lapse before full output voltage appears, due to warmup of tube filaments. A low output voltage (depending on the load applied to the unit) appears as soon as the power is applied to the unit. (See also Starting Circuitry below.)

STARTING CIRCUITRY

On some larger models, special provisions are made to improve the ability of the Regulator to start up under heavy load (such as Power Factor loads) and low input voltage. (See figures 2B and 2C.) Without these auxiliary means, the Regulator might not be able to start up without removing some of the load from the output (as the tube filament voltage is supplied by the output which is low during warming).

For models employing the circuitry in Figure 2B, V2 filament receives its power from transformer T5 which is connected to the input power line. This voltage is regulated by the ballast tube V4 to hold approximately ±5% on the V2 filament. Also in this circuit, V3 (rectifier tube) is replaced by a selenium rectifier stack which of course requires no filament supply. See instructions under V, "Maintenance and Trouble Shooting," for replacing V4.

For models employing the circuitry in Figure 2C, the filaments of V2 and V3 are operated from the unregulated input line during the warmup period in order to obtain adequate voltage. After a time delay (obtained from the time delay relay RLY2) the primary of T5 is transferred from the input line to the regulated output voltage by means of the transfer relay RLY1.

TYPE CONSTRUCTION

All Models indicated on Table II as Bench type, are self-contained and require no cabinet for bench operation. A panel can be supplied for mounting in a standard 19" relay rack. For those models indicated as Rack Mount types, a cabinet can be supplied for bench operation.

TRANSFORMER IMPREGNATION

Standard 50 and 60 cycle Regulators are vacuum varnish impregnated in the standard commercial manner. The transformers in "-SF" and 400 cycle models are "Fosterited" for operation under humid conditions. This Westinghouse development, which Sorensen is licensed to use commercially, entails the enclosing of all but one side of the transformer with a viscous resin capping compound. Then, after the transformer windings have been filled with a thin resin by a vacuum process the open side is capped and the transformer is baked.

After a second external coating and baking, the transformer takes on a glazed appearance and is moisture proof.

For very moist applications, "-SH" models (hermetically sealed transformers) are used. In this case, standard "potting" is applied to the transformers. This completely seals the transformers in a metal case, meeting commercial requirements for sealing.

PAINT FINISH

The standard finish on 50 and 60 cycle models is grey wrinkle. The standard for 400 cycle models is black wrinkle.

TABLE II
MISCELLANEOUS SPECIFICATIONS

MODEL	Input Connection	Output Connection	On-Off Switch	Over-Voltage Circuit Breaker and On-Off Switch	Over-Current Circuit Breaker	Input Current at Full Load (Amps), with 115V input for "S" models, 230V input for "-2S" models	Time Constant (sec.)	Net Weight (lbs.)	Type Construction*
150S 150SF	Line Cord	Output Receptacle	Yes			2.6	.05	25	Self Contained May Be Rack Mounted with the addition of a panel
250S 250SF						3.6		47	
500S 500SF						7.0		47	
500SH						7.0		66	
1000S 1000SF					Yes	13.5	.1	75	
1000-2S 1000-2SF						7.0		75	
1000SH						13.5		88	
2000S	Terminal Board			Yes		27.0	.2	120	Chassis for Rack or Cabinet Mounting
3000S						40.0		155	
3000SH						40.0		240	
3000-2S						20.0		120	
5000S **						67.0		195	
5000-2S **						34.0		195	
10000S	Conduit Box			Over-Voltage Circuit Breaker Only		135.0	.3	525	Self Contained for Floor Operation
10000-2S						68.0		525	
15000S						200.0		900	
15000-2S						100.0		900	
D250 SAN	AN Connector					3.6	.2	21	Shock Mounted for Airborne Use
D500 SAN						7.0		24	
D1200 SAN	Terminal Board		Yes		Yes	16.0		38	
D2500 SAN					Yes (also On-Off Sw.)	33.0		58	

* See also Text under Miscellaneous Specifications.

** For Complete Service Information, see Manual No. 110.

III. INSTALLATION AND OPERATION

Grounding Precautions

The chassis is isolated from the input and output terminals and it is recommended that the chassis and case be grounded. The input is not isolated from the output as evidenced by the circuitry as shown in Figures 1 and 2.

For safety reasons it is recommended that the user provide a ground connection from the electrical wiring ground (BX cable or pipe) to the chassis of the Regulator.

On models up to 1000VA capacity, the input power is applied by means of a line cord utilizing a three-prong plug. Since the third prong of this plug is connected to the Regulator chassis, connection of the line cord to the appropriate receptacle automatically grounds the equipment. If the user does not have three prong outlets available, he should use an adapter. The user should make sure that the extra wire (coded green) coming out from the adapter, is solidly grounded to the power line wiring system. The 400 cycle Models D-250 SAN and D-500 SAN use an AN connector with a ground connection inside. The same grounding precautions should be observed.

On some models, the 3-wire cord or the "Ground" terminal is not supplied. In such case the user should attach a ground wire to the chassis or frame, running this wire to the power line wiring ground.

Power Connection

The input power is supplied by using the flexible line cord on models below 1200VA capacity (except D250SAN and D500SAN). On 1200VA units and larger, the input power is supplied by using the input terminals. For safety reasons, it is recommended that all 115 volt Regulators of 1200VA and larger sizes be connected to the power line supply observing the following precautions:

Connect the Input Terminal which is marked "Common" to the grounded side of the 115 volt power line. The grounded side of the power line wiring is generally coded by white wiring and by bright plated (such as nickel) connectors. All loads and load wiring should be connected so that the side which is intended to be the ground side of the line is connected to the output terminal marked "Common"; hence, the white wire feeding the load circuits should be connected to this "Common" terminal of the Regulator output.

These precautions guarantee that the ground side of the line is carried through the Regulator and out to the various loads.

It is to be noted on 230 volt Regulators that normal power line wiring practice is for both sides of the line to be ungrounded. Therefore, no precautions are necessary in connecting up the Regulator and loads, except for grounding as covered in section above. If one side of the 230 volt line is grounded, then observe the same precautions as noted above for 115 volt units.

In case of doubt, the user should consult his local power company for grounding precautions. It is also suggested that local wiring codes be observed in this respect.

Switch Installations Required With the Sorensen Regulators

All 50 and 60 cycle Models below 2000VA incorporate toggle ON-0FF switches in the Regulator. This switch completely disconnects both sides of the input power line from the Regulator. Hence, in the OFF position, there is no shock hazard on the load; however, before working on the Regulator, the line cord must be disconnected. On the 2000VA to 5000VA Regulators, there is an ON-OFF bakelite shaft switch. This is a single-pole device which disconnects only one side of the Regulator from the line. On 115 volt Regulators, there is still one side of the line connected to the load in the OFF position. However, if the precautions given above have been observed, this is then the grounded side of the line and no shock hazard exists on the load. Nevertheless, before working on the Regulator, the input power should be cut off by means of an external line-disconnect switch provided by the user.

On 230 volt Regulators, when this switch is in the OFF position, one side of the ungrounded line still remains connected to the load; hence, a shock hazard still exists on the load. It is then essential that the customer provide an external line-disconnect switch, and turn this off before working on either the load or the Regulator.

The models of 10,000VA and 15,000VA do not have any ON-OFF switch provided on the Regu-

lator. The user must provide an external line-disconnect switch. This switch must be turned off before working on the load or the Regulator.

Concerning the 400 cycle models, the 250VA and 500VA models have no ON-OFF switch and the user must provide an external line-disconnect switch. On the 1200VA model, a toggle ON-OFF switch is used to disconnect both sides of the input power line. On the 2500VA model, the ON-OFF switch is also the thermal over-current breaker. Note also on this model that this switch opens only one side of the input line. Hence, an external line-disconnect switch should be used before touching the Regulator circuitry or load.

Output Connection

On units with a capacity of 1000VA or less, the regulated output voltage is available at the rear of the unit by inserting a suitable plug into the dual receptacle provided. The upper pin side of the output receptacle shall be the "common" side of the output. On larger units, suitable terminals are provided. On the 400 cycle models of 250VA and 500VA capacity, the output is available by means of an AN connector on the unit.

Protective Devices

The fuse on the front panel is provided only as a protection for the control circuit components in the event of an internal failure.

The models below 1000VA capacity do not contain any over-current protection so that the user must make sure the load connected to the Regulator does not exceed the VA rating (e.g., the 150S must not be connected to any load over 150VA). An external fuse can be supplied by the user, if desired.

All models 1000VA and larger contain an over-current device (thermal snap-action disconnect switch) which prevents over-loading of the Regulator.

This device permits overloads for a few seconds duration of several times normal rating, but it disconnects the load from the regulator if the overload persists. Smaller overload currents can exist for much longer periods before the thermal protector operates. The over-current device resets itself automatically after the device has cooled off for a few minutes.

Generally this device is mounted under the chassis and is not available for manual operation. In the case of the 2500VA 400 cycle model this device is part of the ON-OFF switch and must be reset manually.

All models 2000VA and larger (except the 2500VA 400 cycle model) contain an over-voltage relay which serves as the ON-OFF manual switch (located on the front control panel). This switch is principally used for turning the Regulator on and off. (Note, however, grounding precautions above.) Also, this switch is magnetically operated to turn off the Regulator automatically in case of any circuit failure which causes the Regulator output voltage to rise above 130 volts. In case of such automatic trip, the user should reset this switch to ON position. If the device again trips off, there is something defective in the Regulator which must be repaired. The voltage at which this relay trips out (130 to 135 volts) may be adjusted by the 25 or 50 watt adjustable resistor in series with the relay coil (see Figure 2). This adjustment can be accomplished only if an accurate voltmeter and a variable input voltage source are available. (Normally the factory adjustment need not be changed unless replacing these parts.) Disconnect the relay coil and its series resistor from the Regulator. Apply 115 volts from the "Variac" source to the resistor-coil series combination and adjust the resistor until the relay trips from ON (set manually) to OFF just as the voltage reaches 130 (260 in "-2S" units).

It is to be noted that in the 10,000VA and 15,000VA Regulators, the over-voltage switch is mounted behind the control panel. On these models the over-voltage switch does not disconnect the input power from the Regulator and cannot be used as a manual ON-OFF switch. Instead, if over-voltage failure occurs, this switch trips off and disconnects the control circuit power. This tripping action partially disables the Regulator causing the output voltage to drop to 60 to 110 volts depending on the load.

Should this switch trip off, then the pilot lamp on the front panel will go out indicating trouble.

CAUTION: DO NOT TOUCH THE REGULATOR OR LOAD WIRING UNTIL THE INPUT POWER IS DISCONNECTED BY AN EXTERNAL LINE SWITCH.

As optional equipment (at extra cost) the Regulators of the 10,000VA and 15,000VA sizes can be supplied with an Interrupter Contactor. This Contactor disconnects one side of the power line whenever the over-voltage relay trips; hence, the load

voltage and the Regulator receive no voltage. This optional Contactor provides more positive protection than the standard control-power disconnect in that all power to the Regulator is interrupted instead of only control-power. It is recommended for critical applications that this optional Contactor be used.

Nameplates

Sorensen strongly suggests that the nameplate be retained if the Regulator is incorporated into other equipment. This will eliminate later difficulties if service or parts are required.

Auxiliary Transformers for Use With the Regulator

Sorensen & Co., Inc., can supply step-down transformers to permit the operation of a 115 volt Regulator from a 230 volt power line. The windings of these transformers are isolated from each other; therefore, it will be necessary to add a ground connection in order to satisfy the National Electric Code requirement that one side of a 115 volt system be grounded. In such installations all that is necessary is to provide a connection from the "Common" side of the Regulator input and output terminals to the power supply line ground.

Tubes

In bench (self-contained) models, the tubes are shipped installed in their sockets in the unit unless otherwise indicated by a tag on the unit. On rack or cabinet models and floor models, tubes are shipped un-installed in corrugated cardboard. Tube sockets on the regulator are marked with the tube type that is to be used.

Chassis Inter-Connection

On the 10,000VA and 15,000VA models the controller chassis and harmonic filter chassis may be packed separately to prevent damage in shipment. Re-assembly instructions are included with each unit if necessary.

IV. PRINCIPLE OF OPERATION

The operation of the unit can best be understood by referring to the Fig. 2 schematic diagram included as a part of this manual. In the event exact information is required concerning a specific unit, then reference should be made to the schematic covering that particular model. Such schematics are furnished with each unit.

All components used are listed as follows although every one may not be used in a particular unit.

*These descriptions apply only to 500VA and smaller units.

C1 — Filter Capacitor for V2 plate supply.

C2 — Filter Capacitor for bridge HV supply.

C2* — Filter Capacitor for negative (bias) HV supply.

C3 — See C2

C5 — AC capacitor used to resonate with L1 to the third harmonic of the supply voltage, in order to suppress this harmonic.

C6* — Anti-hunt capacitor in feedback network from plate of V2.

C7 — AC capacitor used to resonate with L2 to the fifth harmonic of the supply voltage, in order to suppress this harmonic.

F1 — Control Circuit power supply fuse (panel control).

L1 — AC reactor, See C5.

L2 — AC reactor, See C7.

L3 — AC reactor connected across regulator output to act as a minimum load. Improves no-load stability and regulation.

PL — Control Circuit pilot light (panel light).

R1 — Resistor (resistance wire, cut to size at Final Test) used to compensate the regulation so that effects of input voltage changes are minimized.

R2 — Series limiting resistor in HV bridge supply circuit to limit peak currents in rectifier S1 and Capacitors C2 and C3.

R3 —Antihunt resistor in negative feedback circuit from plate of V2.

R4 & R5 — Bleeder resistor and voltage divider to supply V2 screen voltage.

R6 — Swamping resistor across DC coil of reactor T3. This limits high peak voltages across this coil on surges.

R7 — Parasitic oscillation suppressor.

R8 — Diode adjust resistor (resistance wire cut to size at final test) This resistor centers the output adjustment range of the panel potentiometer R9.

R9 — Output voltage adjustment (panel) potentiometer.

R10 — Resistor in plate circuit of V2 used in the feedback network (anti-hunt).

R11 — Negative temperature coefficient (N.T.C.) carbon resistor in the diode V1 filament circuit. This resistor aids in reducing output voltage changes caused by ambient temperature changes.

R12 — Temperature compensation adjustment resistor (resistance wire cut to size) used to adjust the effect of R11.

R13 — See R10.

R14 — Load resistor connected across regulator output to act as a minimum load, thus improving operation at no-load.

R15 — Load line resistor (stranded insulated copper wire cut to size at final test). Compensates regulation to minimize the variations in output voltage normally caused by load variations.

R16, R17, R18 — Bridge resistors. Working with the plate resistance of diode V1, these 3 resistors establish a voltage-sensing bridge.

R16* — Diode V1 plate load resistor.

R19 — Adjustment resistor in series with SW-1 (below) to enable close adjustment of the over-voltage trip point.

R24 — Filament adjustment resistor used only with ballast tube (see Fig. 2B).

R25* — Bleeder resistor across negative (bias) HV supply.

RLY1 — DPDT relay used to transfer the filament transformer T5 from input line to the regulated output. This is part of the alternate quick-start circuit (Fig. 2C).

RLY2 — 60 second time delay thermal relay SPST. This is part of the alternate quick-start circuit (Fig. 2C).

S1 — Selenium rectifier for HV bridge power supply.

S1* — Selenium rectifier for negative (bias) HV supply.

S2 — Anti-surge selenium rectifier in grid circuit of V2. This device prevents positive-grid operation during regulator warm-up period, which could otherwise cause momentary grid-blocking (and high output voltage).

S3 — Power selenium rectifier used as alternate to V3 (see below) shown in alternate quick-start circuit (Fig. 2B).

SW1* — DPST "ON-OFF" input power switch (panel control).

SW1 — SPST "ON-OFF" input power switch combined with automatic over-voltage trip coil (panel control). If regulator output voltage exceeds the pre-set value, this device automatically turns off the regulator.

T1 — Control circuit power transformer.

T2 — Compensation transformer, coupling the two compensating voltages (from R1 and R15) into the diode sensing circuit (filament of V1).

T3 — Saturable core reactor, in power handling circuit.

T4 — Auto transformer, in power handling circuit.

T5 — Filament transformer to supply regulated filament voltage to V2. This item is used with V4 and S3 in the alternate quick-start circuit (Fig. 2B) and also in alternate quick start circuit (Fig. 2C).

V — AC voltmeter connected across output of regulator.

V1 — Sensing diode.

V2 — Power amplifier tube.

V3 — Power rectifier tube (for V2 plate supply).

V4 — Resistor-ballast regulating tube (for V2 filament supply), used in alternate quick-starting circuit (Fig. 2B).

Power Circuit

The basic power circuit includes an autotransformer T4 and a saturable core reactor T3. The reactor is in series with the primary of the autotransformer across the input terminals. Variation of the impedance of the saturable core reactor will vary the voltage impressed on the primary of the autotransformer and consequently will vary the output voltage.

A decrease in reactor impedance, for instance, will increase the portion of the input voltage impressed on the autotransformer primary and will result in an increase in output voltage.

Conversely, an increase in reactor impedance will result in a decrease in output voltage.

Control Circuit

All that is necessary to achieve voltage regulation is some automatic method of varying the reactor impedance by the right amount to restore the output voltage to its original value at such times as it may vary due to changes in load or input voltage. This action is accomplished by the electronic control circuit.

The basic voltage sensitive element is the Wheatstone Bridge. One arm of the bridge con-

sists of the diode V1, the filament of which is lighted by the output voltage. In some low capacity models only two arms of the bridge show on the schematic diagram. The power supply has the missing two arms by virtue of its arrangement.

The diode is operated in a temperature limited condition. With this arrangement, a small increment of output voltage results in a change in cathode emission and a large change of plate resistance in the diode. The signal voltage of the bridge is applied to the grid of beam power tube V2 which controls the DC saturating current of the reactor.

Operation Sequence

A typical sequence of operations is as follows: Assume a rise in output voltage as a result of reduced load or a rise in input voltage. Increased output voltage results in increased voltage and heating of the diode filament. With increased heating, the diode cathode emission increases reducing the plate resistance of the tube. Since the diode forms an arm of the bridge, a change in plate resistance will change the balance condition of the bridge; in this instance the change results in a more negative potential applied to the grid of V2. The more negative grid signal results in a sharp drop in the plate current of V2 and consequently, reduced saturation of the reactor. Reduced DC saturation of the reactor results in an increase in AC impedance which, as pointed out before, lowers the output voltage.

The above action will continue until an equilibrium is reached wherein the net change in output voltage is sufficient to compensate for the changed circuit conditions in the control circuit. The gain of the control system is of such magnitude that the unit will maintain output voltage within the rated tolerance, while compensating for the rated range of input voltage and load variations.

Rectifiers

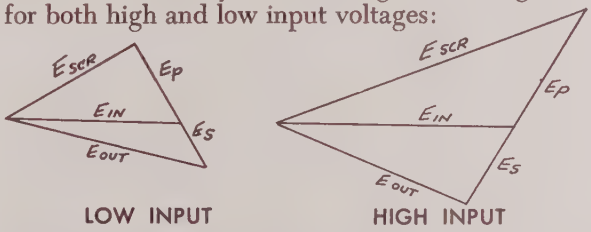
The tube V3 is a rectifier tube for the saturating circuit, and S1 a selenium rectifier for the diode bridge circuit output adjustment. Adjustment of the output voltage is accomplished by the potentiometer in the circuit supplying the diode filament voltage. Variation of the resistance in this circuit varies the value of output voltage required to obtain a given diode filament temperature, and consequently will control the output voltage.

Swamping Resistor

The resistor shown connected across the control coil of T3 is a swamping resistor to absorb inductive surges originating in the DC reactor winding. The winding has a very high inductance.

Phase Relationship

The phase relationships that exist in the power circuit are shown by the following Vector diagrams for both high and low input voltages:



LOW INPUT HIGH INPUT

Escr Voltage across the saturable core reactor.
Ein Input voltage.
Eout Regulated output voltage.
Ep Voltage across primary of the autotransformer.
Es Voltage across secondary of the autotransformer.

V. MAINTENANCE AND REPAIR

Maintenance

During normal life, the unit requires no maintenance or servicing other than the care usually afforded this type of equipment. Vacuum tubes should be replaced at the end of their specified life in accordance with the policies established for the particular application.

Spare Parts

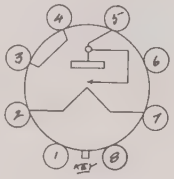
All components in Sorensen Regulators are of a good commercial grade and can be expected to give a reasonably long period of trouble-free service. As the age of the instrument increases, however, some components are likely to deteriorate; we therefore suggest that the customer keep on hand the spare parts as indicated by an asterisk on the Parts List supplied with the unit.

In the event it becomes necessary to replace any part we strongly suggest that the replacement parts be of the same value as the original. Substitute parts should not be used unless we advise that the substitute part will not impair the performance of the instrument.

2AS15A Tube Data

In almost all cases it will be found that if the 2AS15A filament is intact the tube is good; however, for those customers who wish to set up special tests the following data is included:

Filament	1.8 volts DC/AC
	310-335 ma.
Plate	500 volts DC
	.410-.600 ma. DC



Ballast Tube Regulated Filaments

In the event it is necessary to replace V2 or V4 when the circuitry in Figure 2B is employed, proceed as follows:

1. Measure the filament voltage of the 6L6 (pins 2 and 7) or the 807 tube (pins 1 and 5). Use an accurate 10VAC meter, having a sensitivity of not less than 100 ohm/volt, such as the Ballantine VTVM.

If this voltage is between 6.1 and 6.5 volts with 115 volt input to the Regulator, no adjustment is necessary (see step 5 for a final check).

2. If 1 (above) shows the filament voltage is outside of limits, adjust slider on R24 (200 ohm 10 watt adjustable resistor) until voltage per 1 (above) is read. Allow a few minutes after each adjustment for the voltage to stabilize.

3. If the voltage remains below 6.1 volts after step 2 (above), unsolder one wire to R24 and recheck. Leave this wire off if voltage is per 1 (above). Tape the end of the unused wire.

4. If voltage in 3 (above) is still below 6.1 volts, then it is necessary to reconnect R24 so that it is wired across pins 2 and 7 of the ballast tube. It will then be possible to adjust R24 for the correct voltage per 1 (above). This connection should only be used as a last resort.

5. At 115 volts input, the ballast tube should not glow noticeably and the voltage across it should not exceed 8.2 volts. Otherwise, the life of the ballast tube will be unduly shortened.

Compensation Procedure

Definition of compensation: Compensation in Isotronic terms means a reduction of the amount of voltage deviations caused by line or load changes.

The regulator has several components that are factory adjusted to the optimum value and readjustment in the field is not recommended. However, a brief description of the procedure is given to be used in an emergency:

1. Loosen one end of R1 from the terminal board on which it is mounted and remove the insulation. Using a clip lead jumper, connect the compensating wire to the terminal just disconnected.

2. Replace R15 (load line) resistor with a piece of the same size wire of greater length.

3. With a one half load on the unit, set the output voltage to 115.00V with 115V input.

4. Adjust R1 (by sliding the clip lead) so that a minimum output voltage change is observed when the input line is varied from 95 to 130 volts.

5. Remove the one half load, and use a one-tenth load in its place. Repeat step 3

6. Repeat steps 3 and 5 at full load.

7. Progressively reduce the length of R15 while observing the output voltage change with the load varied. When no apparent change takes place, the proper length of R15 has been found.

8. Insulate and replace R1.

Note: When the unit is in specs., the proper length of R8 should be determined. When R8 is the proper length, the output voltage can be varied from less than 110V to more than 120V. R8 makes the output voltage rise.

If the output of the unit drops with an increase in load, and a minimum leagth of R15 fails to bring the unit into specs., reverse the T2, Compensating Transformer connections across R15, and progressively increase the length of R15.

Adjustment of R12 (not found in 400 cycle models) is made to secure optimum temperature compensation. This should not be adjusted since the optimum value cannot readily be determined in the field. However, in an emergency the value of this should be such that the output voltage drops 6 to 8 volts (12 to 16 volts in "-2S" models) when the trial value of R12 is shorted out under full load.

Repair

In the event of malfunctioning of the unit due to deterioration or failure of any of its component parts, a systematic checking procedure will provide the quickest and surest method of locating the difficulty. The following section gives systematic checking procedures which should be followed in

locating sources of trouble. It should be remembered however that the personnel doing the trouble shooting should be familiar with electronic equipment in order not to cause additional trouble or damage to the instrument.

CAUTION

DANGEROUS VOLTAGES EXIST IN THIS INSTRUMENT. PLEASE OBSERVE APPROPRIATE PRECAUTIONS.

Typical circuit voltages are indicated on the appropriate schematic drawing supplied with each unit. Also, see Table III. All voltage measurements should be taken with 1000 ohms/volt voltmeter except grid voltages which should be measured with an electronic type voltmeter.

THE FIRST STEP IN TROUBLE SHOOTING SHOULD BE TO REPLACE EACH TUBE WITH ONE KNOWN TO BE GOOD. IN MANY CASES THIS WILL BE ENOUGH TO CORRECT THE DIFFICULTY.

Symptom A — High Output Voltage

Possible Cause:	Check:
	Isolate difficulty by removing V2 from its socket. If the output voltage drops the trouble is in the control circuit or the diode sensing circuit.
Open Diode Sensing Circuit (See 0-0-0-0- Figs. 1 and 2)	Determine if the diode sensing circuit is open at any point.
Shorted Elements in Tube V2	Replace tube with one known to be good.
Improper Circuit Voltages	Test the circuit voltages at points where the voltages are indicated on the schematic. If abnormal voltages exist (more than 20% deviation) check the contacts, connections and resistance values of all associated components.

Symptom B — No Output Voltage

Possible Cause:	Check:
Open in the Power Circuit (See––– Figs. 1 and 2)	Test for an open circuit in one of the following components: on-off switch, circuit breaker, AC windings of T3, primary and secondary of T4.
Faulty Over-Voltage Circuit Breaker	If a series resistor is used it may be readjusted; otherwise, the breaker must be replaced.

Symptom C — Low Output Voltage

This condition indicates the failure of control circuit to supply sufficient saturating current through T3.

Possible Cause:	Check:
	Test continuity of fuse; replace only with fuse of similar value.
Tube Failure	Replace with tubes known to be good.
Open DC Coil on T3	Open one lead and check for continuity.
Improper Circuit Voltages	Test the circuit voltages at points where the voltages are indicated on the schematic. If abnormal voltages exist (more than 20% deviation) check the contacts, connections and resistance values of all the associated components.

Symptom D — Drift With Age of the Range of Output Voltage

This condition indicates a variation of tube characteristics with age.

Check:

Replace tubes with spares known to be good.

Symptom E — Reduction of Regulation Range or Poor Regulation in General

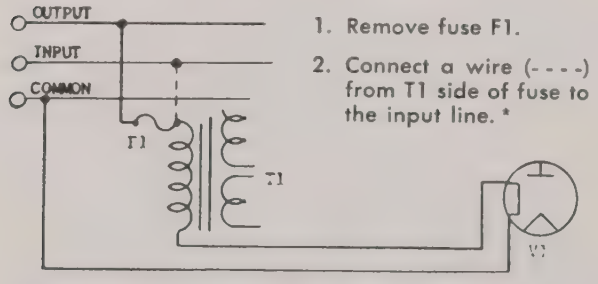
These conditions may be the result of deterioration or failure of various components of the control circuit.

Check:

1. Test tubes or replace with spares.
2. Test the DC power supply voltages.
3. Test the control circuit in general for loose connections, shorts, or damaged parts.
4. Test voltage and resistance values. Check capacitors by replacement.
5. The output voltage adjustable potentiometer may cause irregular output adjustment. Turn the potentiometer shaft several times in both directions as far as it will go. This is a very low resistance adjustment, and the contacts can oxidize enough to cause uneven control.

USEFUL SERVICE HINT

Inasmuch as the Regulator control circuit is powered from the Regulator output, it will be apparent that in the event of difficulty (such as low output or high output), the control circuit voltages will tend to follow the output voltage. In such event, it is difficult to interpret differences between the actual voltages and those indicated on the schematic diagram. In order to localize the source of trouble, it may be convenient to temporarily transfer the primary of the control circuit power transformer (T1) from the Regulator output to the input line. The temporary changes necessary are shown below.



1. Remove fuse F1.
2. Connect a wire (- - - -) from T1 side of fuse to the input line. *

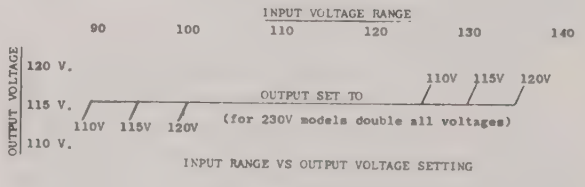
*On some models, F1 is located in the lead to common, hence it is necessary to unsolder the wire from T1 Py. to output and connect this wire to the imput terminal.

In this manner, the circuit voltages will more nearly approximate the normal voltages, and any deviation in excess of 20% should be investigated.

IN THE EVENT OF SERIOUS DIFFICULTY OR DAMAGE TO THE REGULATOR, WE SUGGEST THAT CONSIDERATION BE GIVEN TO RETURNING IT TO THE FACTORY FOR REPAIR.

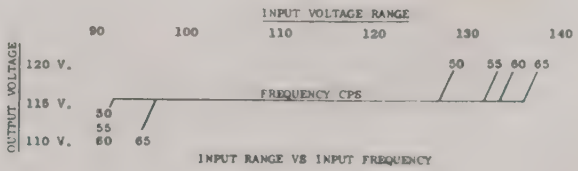
Input Voltage Range

It is apparent from the following graphs that output voltage setting, input frequency, and load power factor have an effect upon the input voltage range. From the graph immediately below it may be seen that if the output voltage is set to 110 volts, the input range will shift to 90-125 volts.

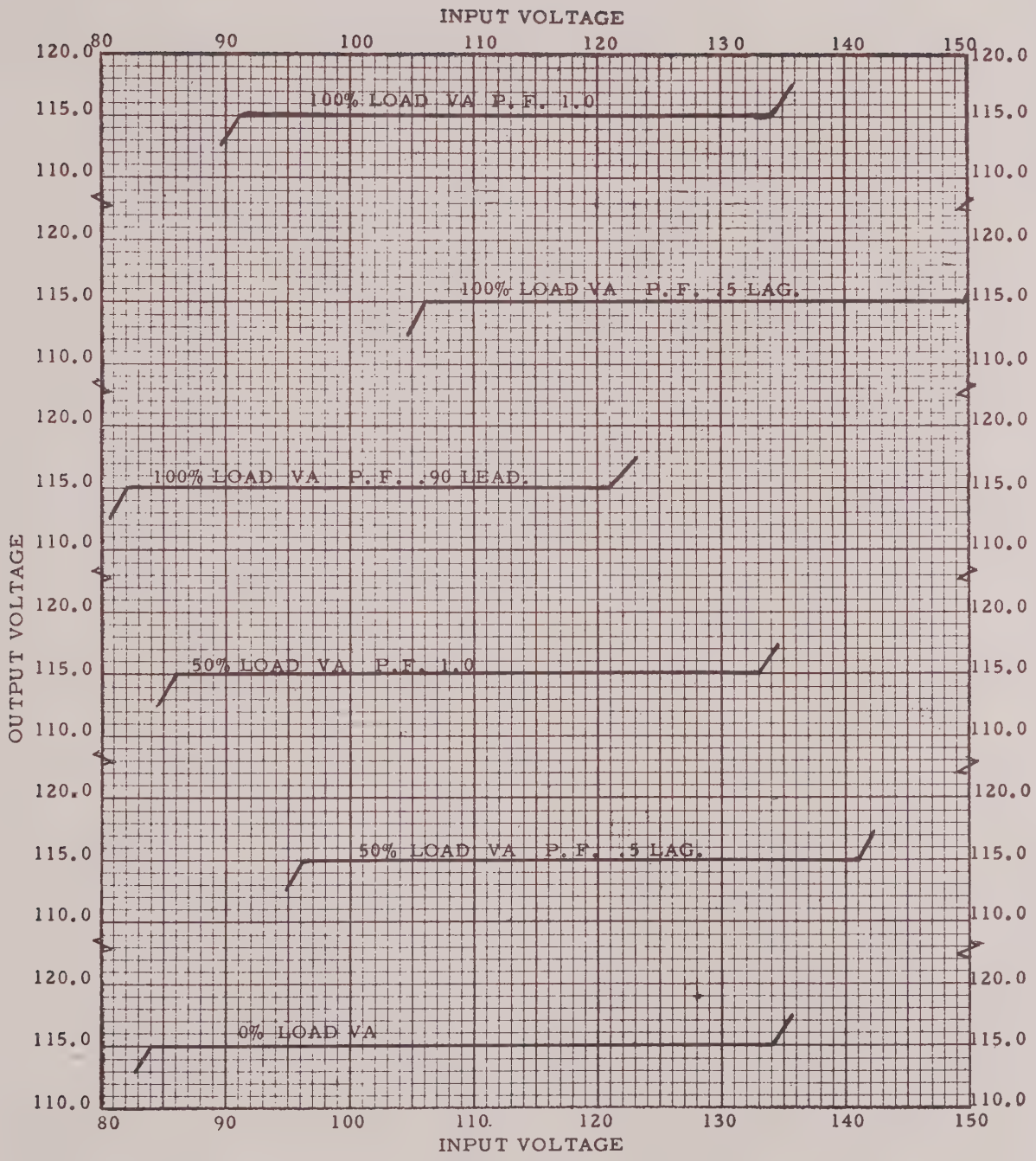


GRAPH A

If the input frequency changes, the input voltage range will also be affected as indicated on the following graph.



GRAPH B



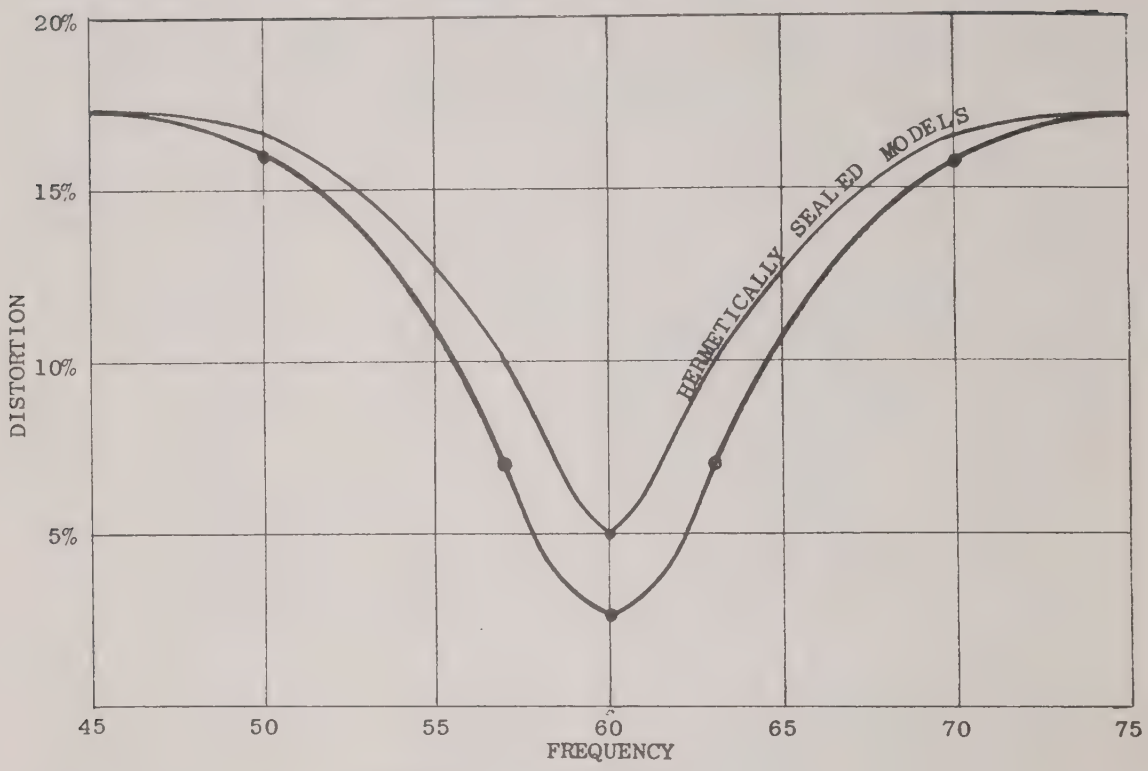
Input Range vs. Load and Power Factor Change

(In "-25" models, double all voltages)

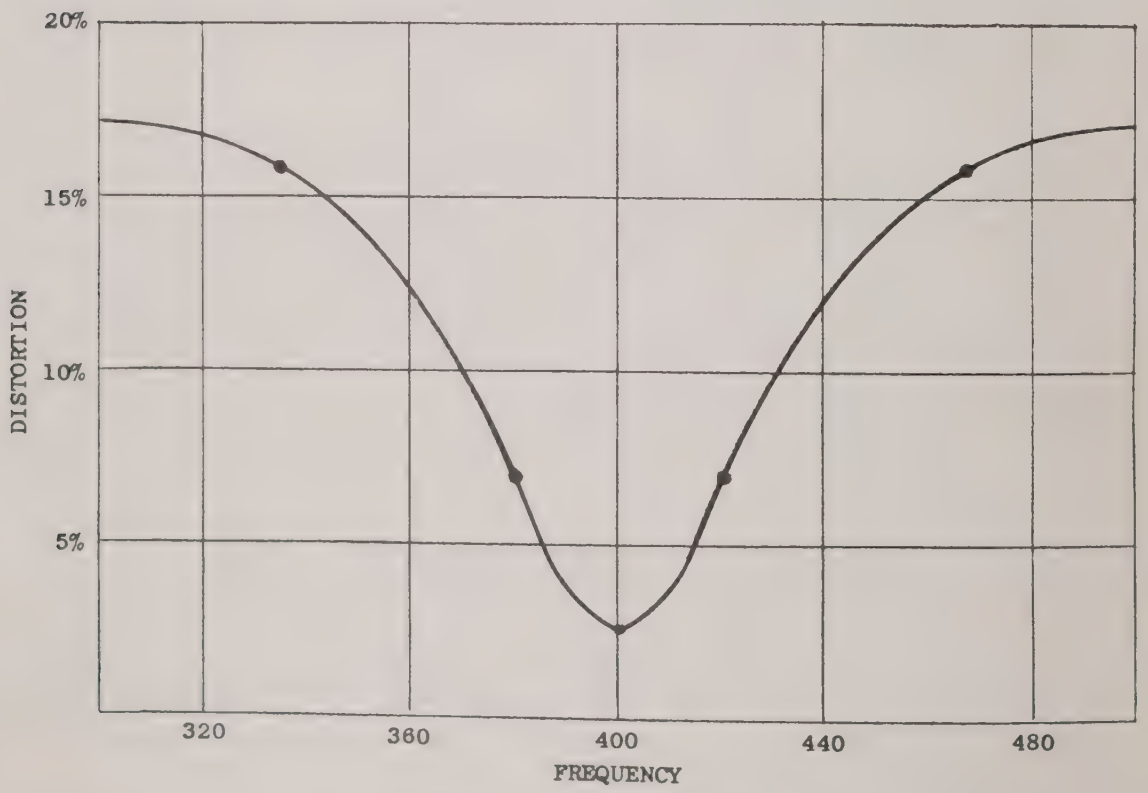
GRAPH C

Output Distortion vs. Frequency Changes

(under worst conditions of line and load)



GRAPH D — 50 and 60 cycle models



GRAPH E — 400 cycle models

TABLE III

VOLTAGE MEASUREMENTS

Because the voltages noted on the schematic drawing furnished separately with this manual were taken under fixed conditions of input, output, and load it may not be realized that under other conditions there will be some variation in the voltages existing at any point. Below is a set of voltages taken from a Model 1000S regulator and while these voltages may not apply precisely to other models the degree of variation is about the same.

Checks made with output at nominal (115 volts)	ZERO LOAD			500 VA LOAD Unity P.F.			FULL LOAD Unity P.F.		
	95 Volts Input	115 Volts Input	130 Volts Input	95 Volts Input	115 Volts Input	130 Volts Input	95 Volts Input	115 Volts Input	130 Volts Input
V2 Plate E	440	450	450	370	410	430	290	360	410
V2 Grid 1 E	−46	−53	−55	−35	−43	−49	−25	−35	−44
V2 Grid 2 E	335	340	340	310	320	330	285	305	325
B+	450	462	462	440	450	460	420	435	460
Bridge + E	400	405	405	410	410	415	400	405	410
Bridge − E	−385	−385	−385	−380	−380	−385	−380	−380	−390
AC Volts Across DC Coil of T3*	40	41	35	39	48	50	34	46	57
AC Volts Across AC Coils of T3	51	120	173	95	180	230	100	192	240
T4 Py E	60	18	45	93	122	135	100	137	150
T4 Sy E	21	6	16	33	47	52	33	52	57
L1 E AC	15	16	24	28	47	52	16	89	125
L1 Series Cap E AC	70	20	65	96	145	175	105	165	205
L2 E AC	3.4	5.6	15	8	10	13	9	18	27
L2 Series Cap E AC	60	19	47	95	125	140	102	148	160

Measurements taken with a 20,000 ohms/volt DC voltmeter and 1000 ohms/volt rectifier type AC voltmeter.

*Use series capacitor to block DC potential.

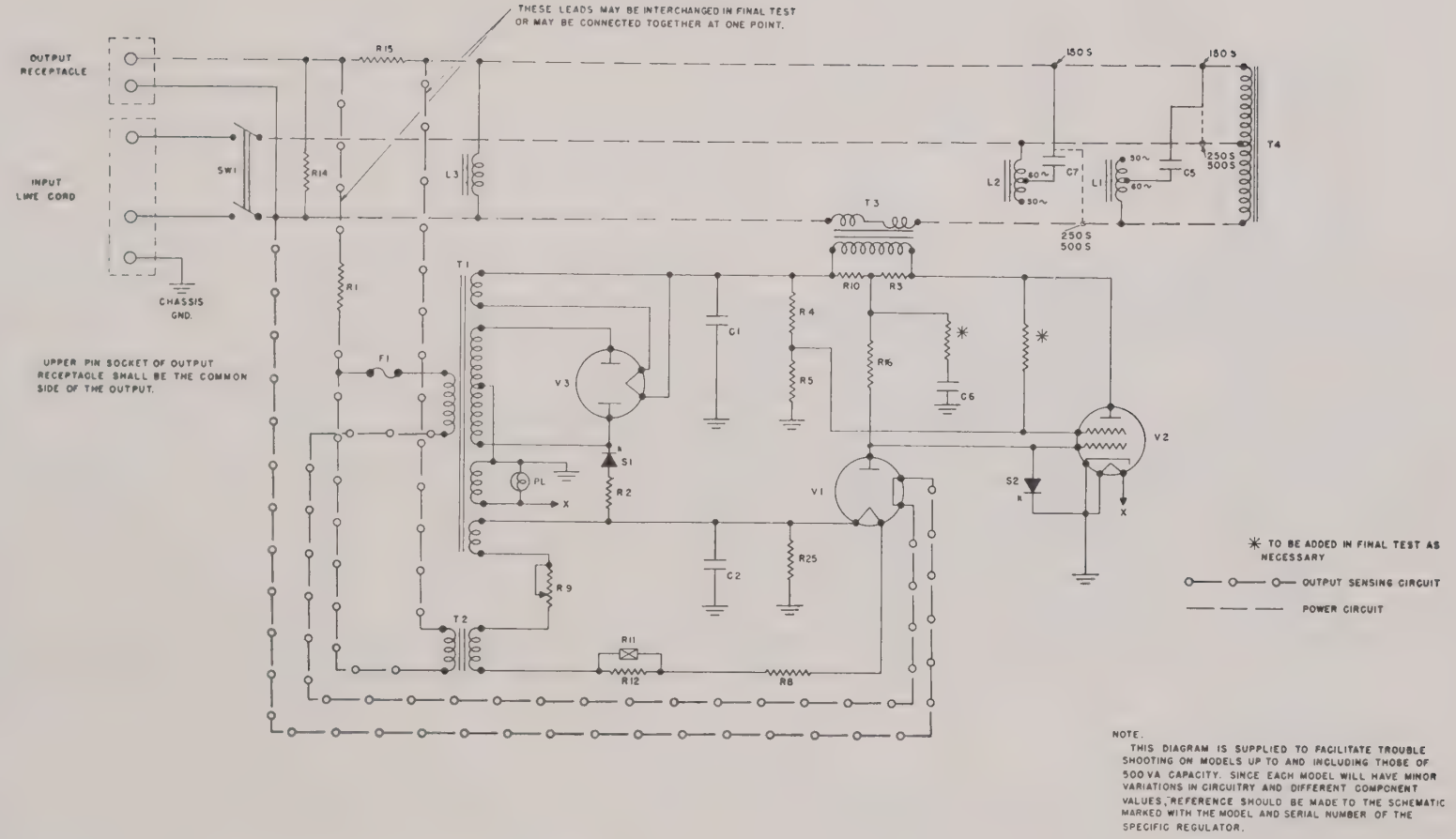


FIG. 1 — REPRESENTATIVE CIRCUIT DIAGRAM FOR SMALLER VA CAPACITY A.C REGULATORS

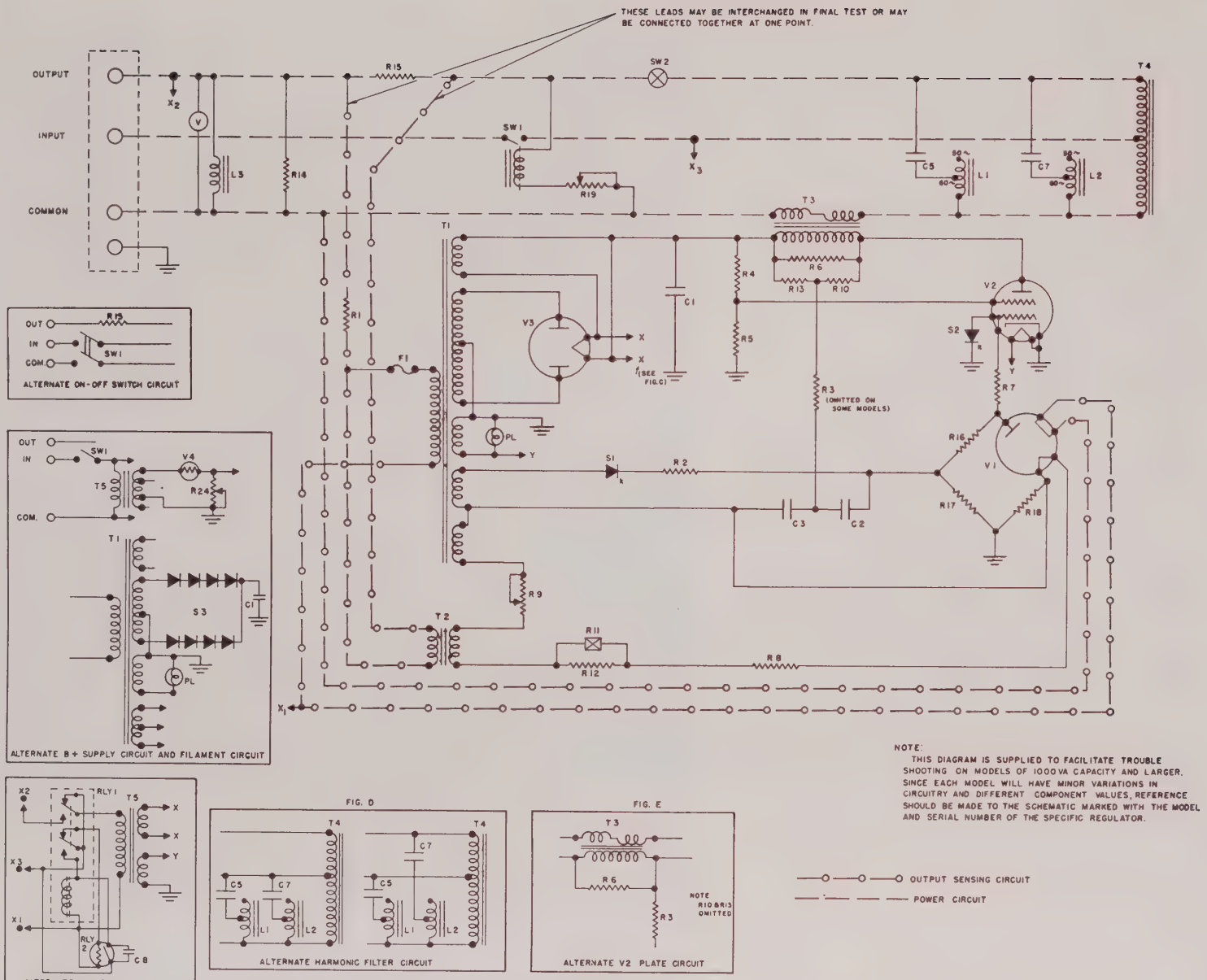
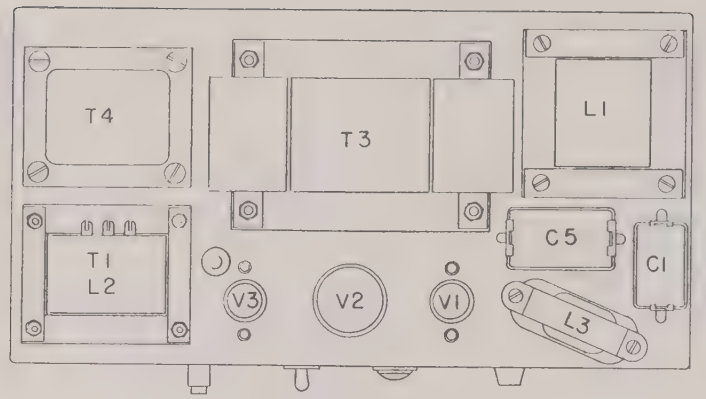
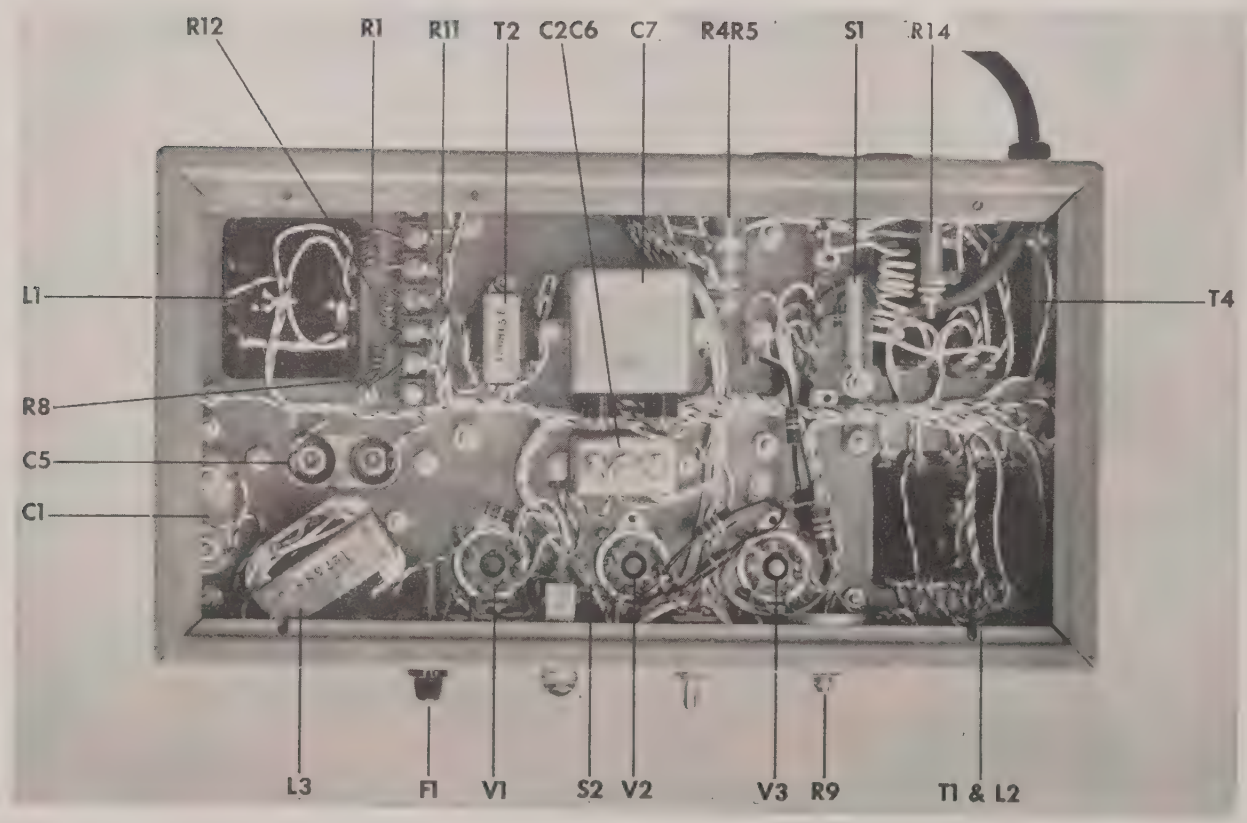


FIG. 2 — REPRESENTATIVE CIRCUIT DIAGRAM FOR LARGER VA CAPACITY A.C. REGULATORS

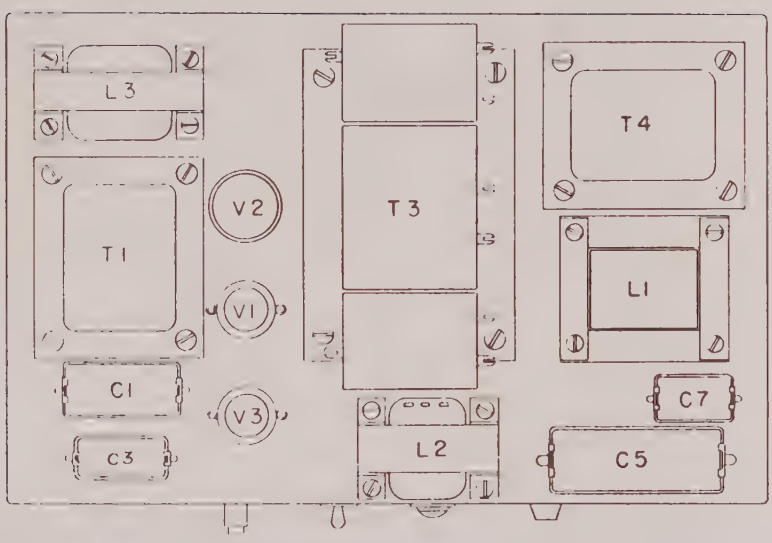


CHASSIS — TOP VIEW

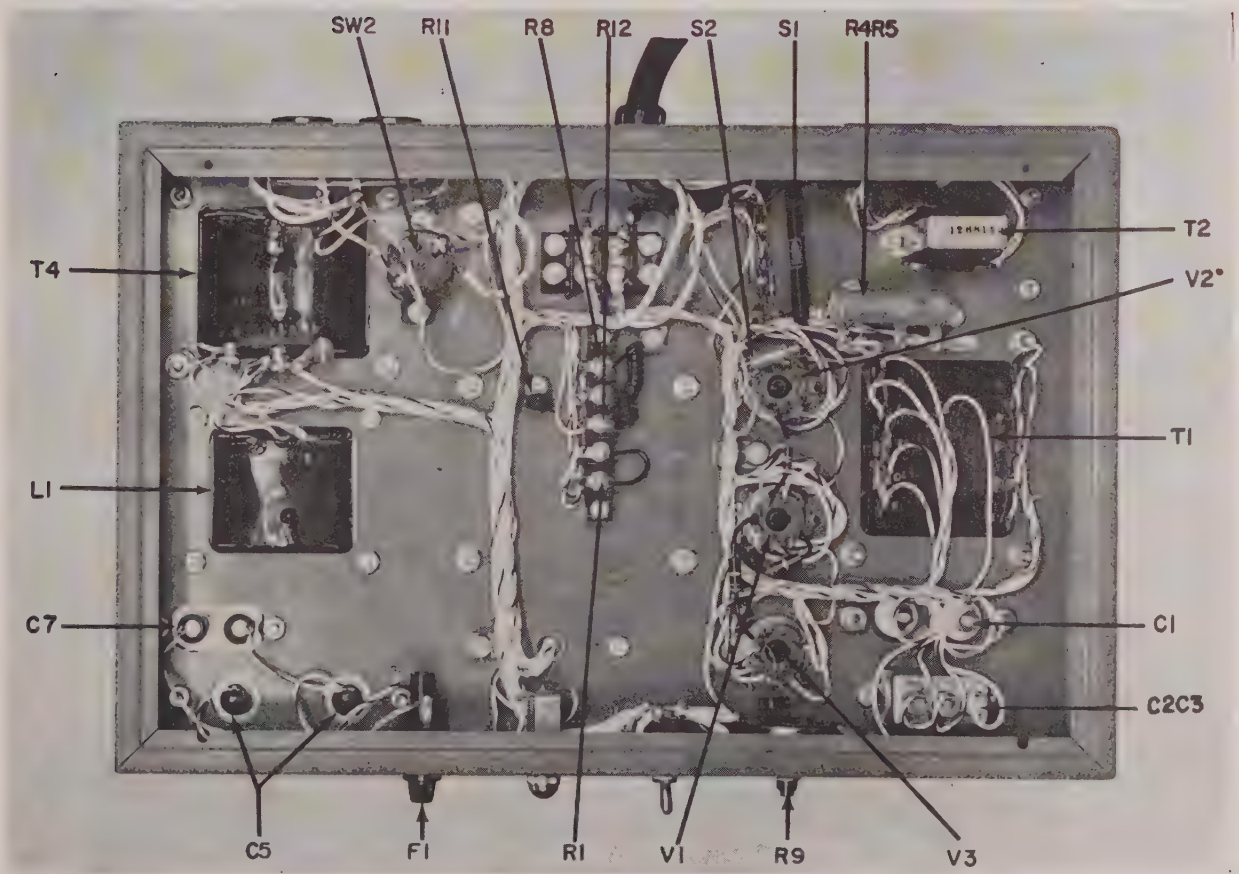


CHASSIS — BOTTOM VIEW

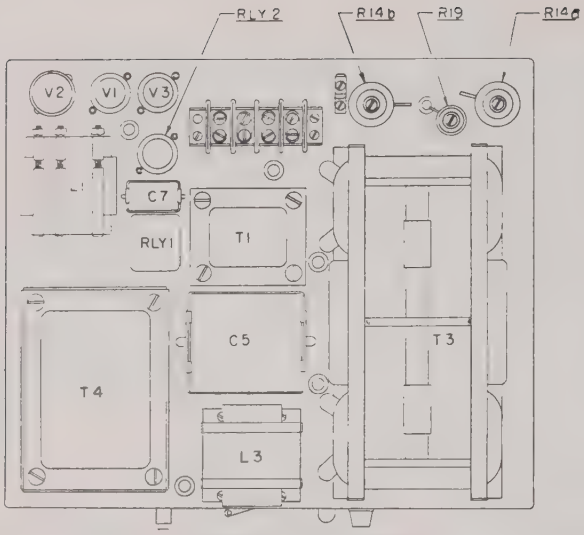
Model 250S at Serial 02-1525



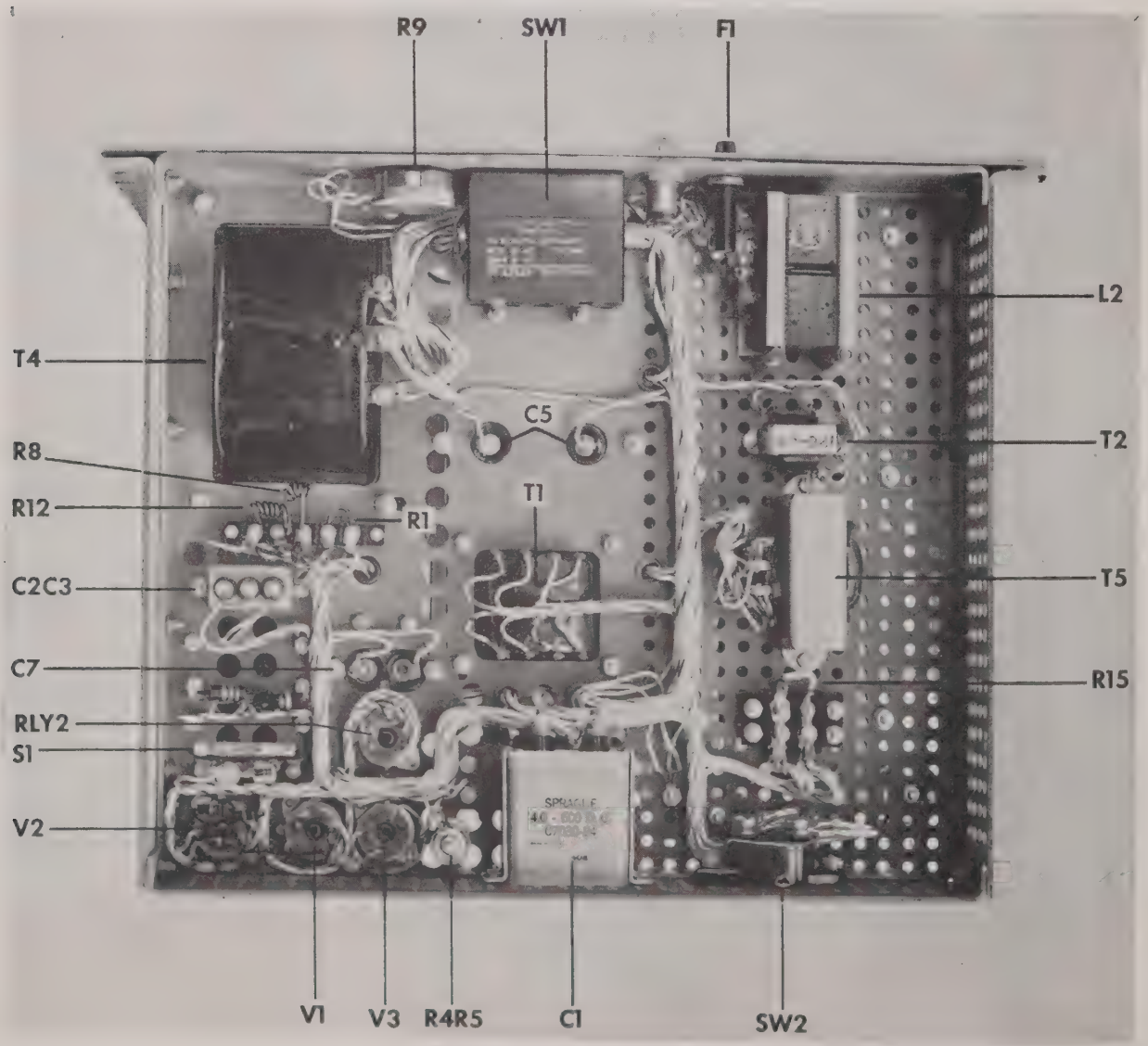
CHASSIS — TOP VIEW



CHASSIS — BOTTOM VIEW
Model 1000S at Serial 1-6631



CHASSIS — TOP VIEW



CHASSIS — BOTTOM VIEW

Model 3000S at Serial 3-1117

NOTES

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